Heaps, Indexes and Execution Plans

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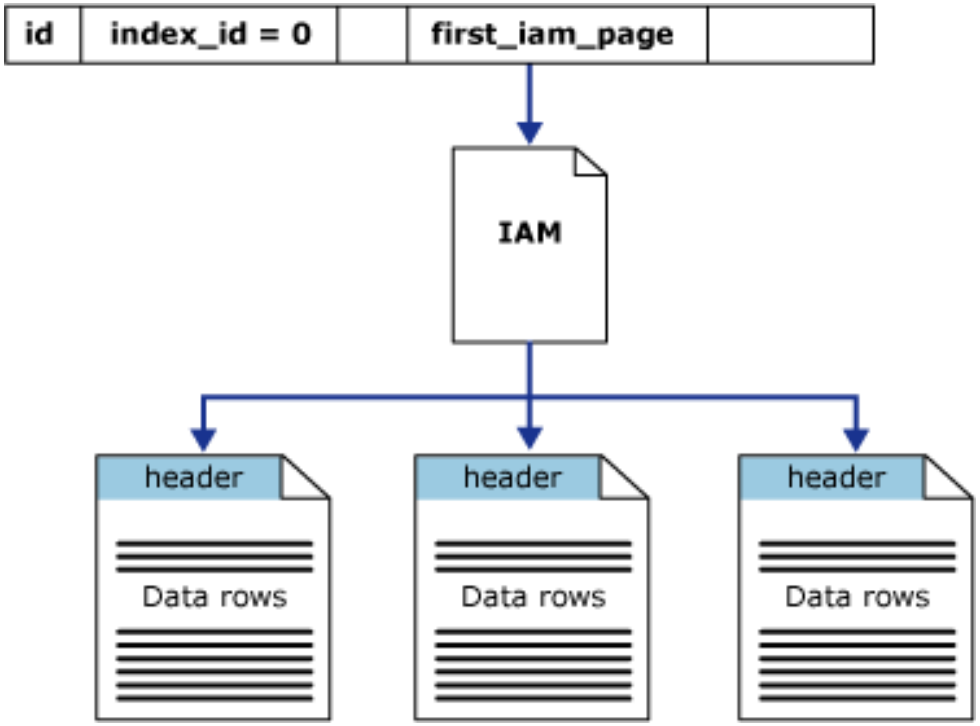
Agenda

- Heaps
- B-Trees
- Clustered Indexes
- Non Clustered Indexes
- Execution Plans

What is a Heap?

* A heap is a table without a clustered index.
* index_id = 0
* SQL Server uses the IAM pages to move through the heap.
* The data pages and the rows within them are not
  in any specific order and are not linked
* The only logical connection between data pages is the information
  recorded in the IAM pages

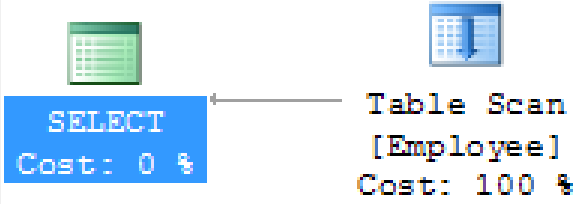


Reading records from Heap

```
-- see the execution plan and observe the operator
select * from Employee where intEmpId = 10010
```

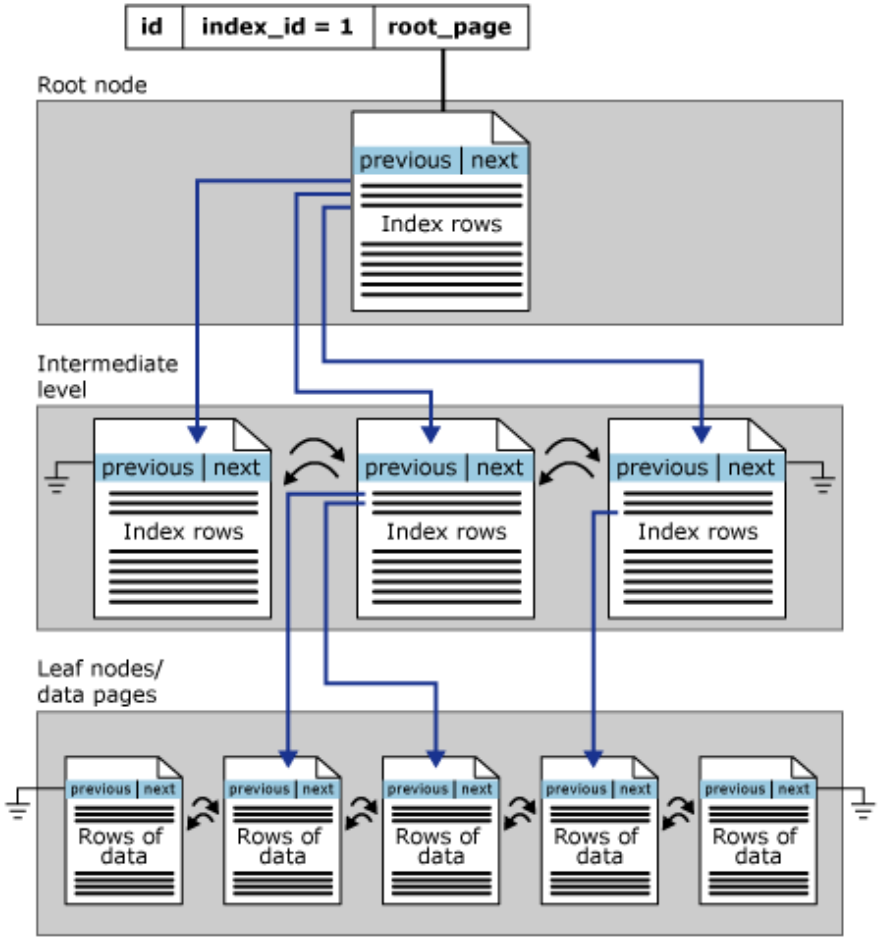
Messages | Execution plan

```
Query 1: Query cost (relative to the batch): 100%
select * from Employee where intEmpId = 10010
```



What is a B-Tree?

B-Tree – This structure helps to find the records quickly



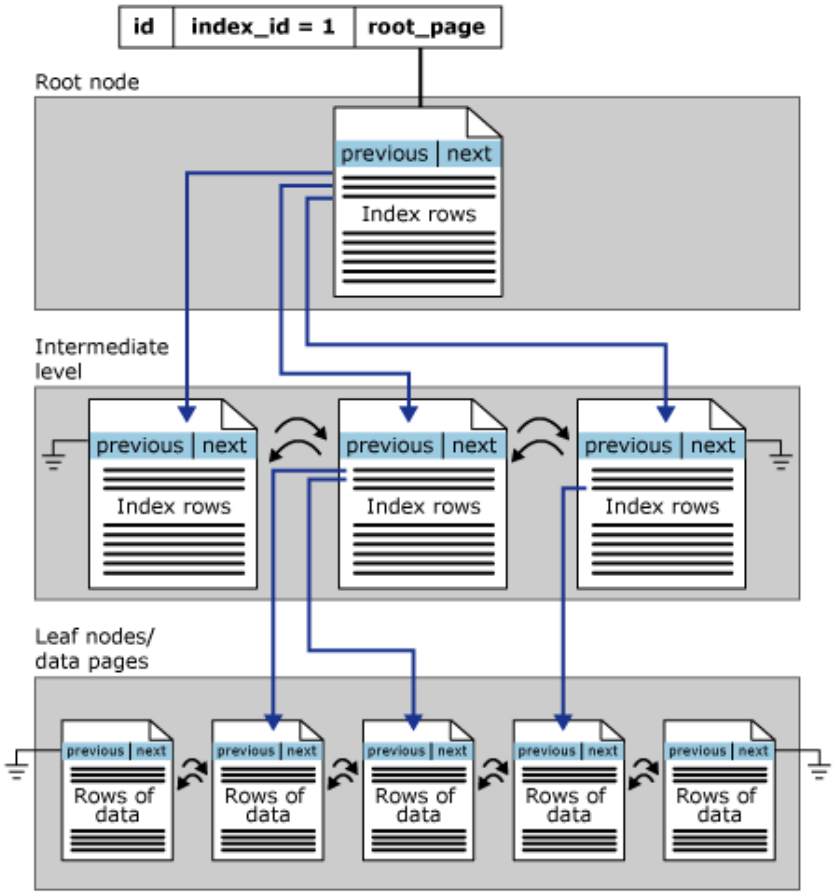
In SQL Server

Clustered Index and Non Clustered Indexes

Are using B-Tree Structure

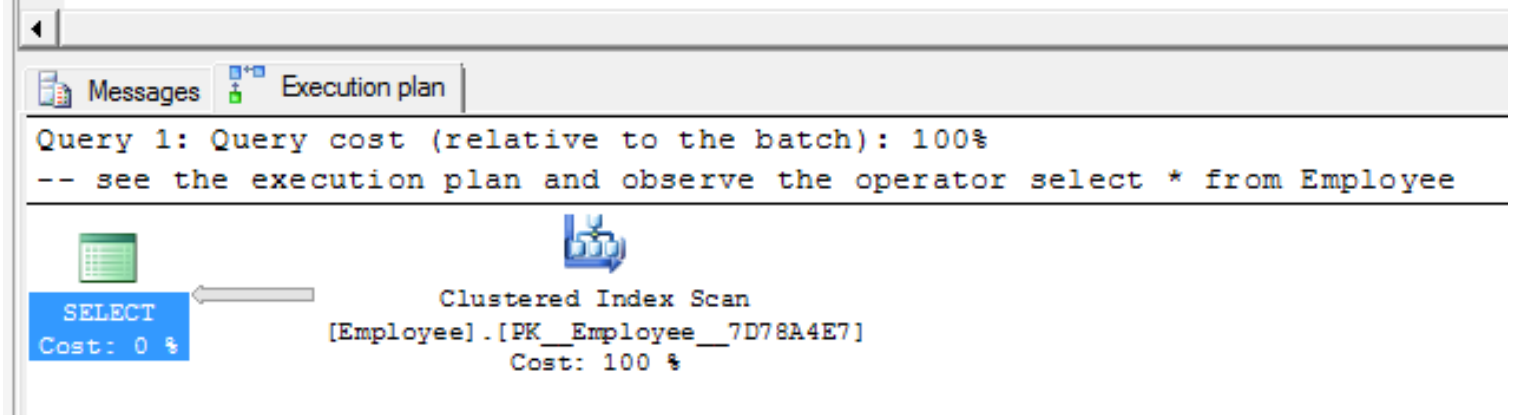
What is a Clustered Index?

- Index_id = 1
- Records are sorted based on CI Key
- Only one Clustered Index per table
- Root and Intermediate pages have Index keys
- Leaf node have actual data pages
- Carefully choose the CI Key

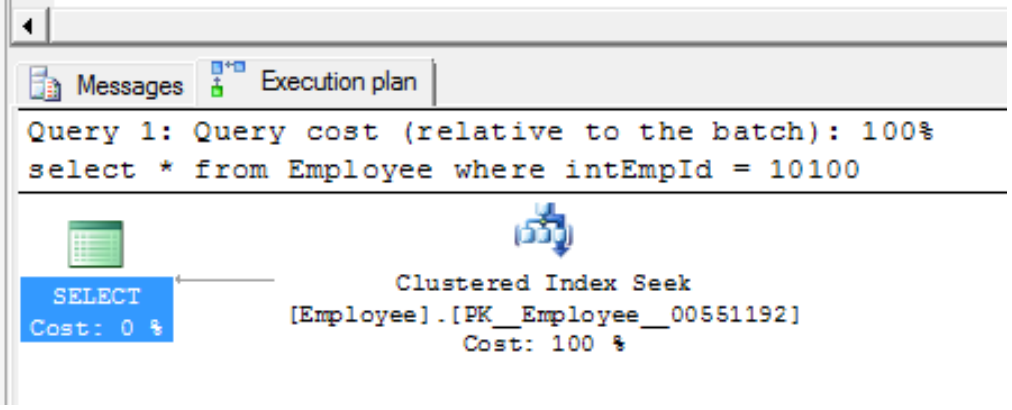


Reading records from Clustered Index

```
-- see the execution plan and observe the operator
select * from Employee
```

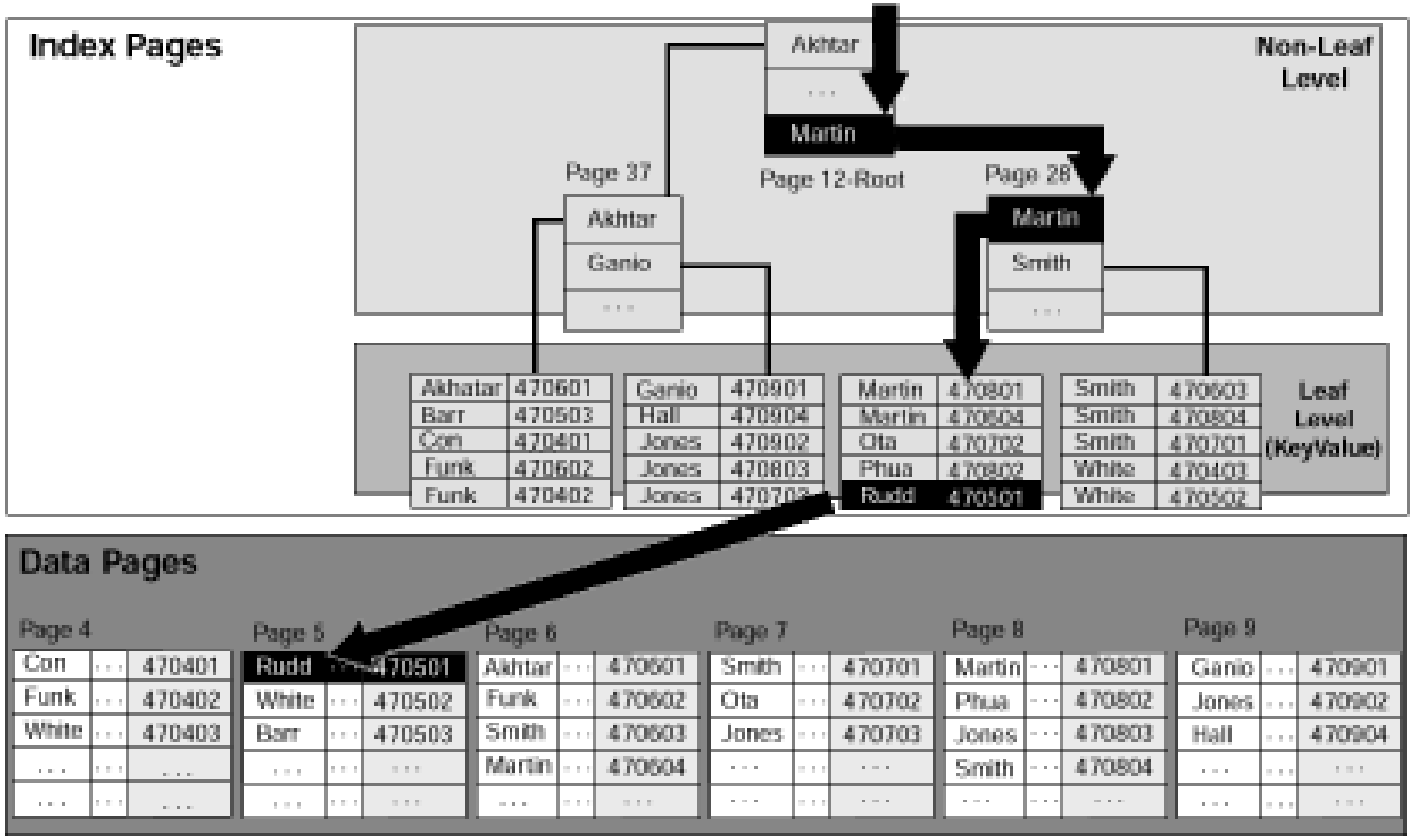



```
-- see the execution plan and observe the operator
select * from Employee where intEmpId = 10100
```



What is a Non Clustered Index?

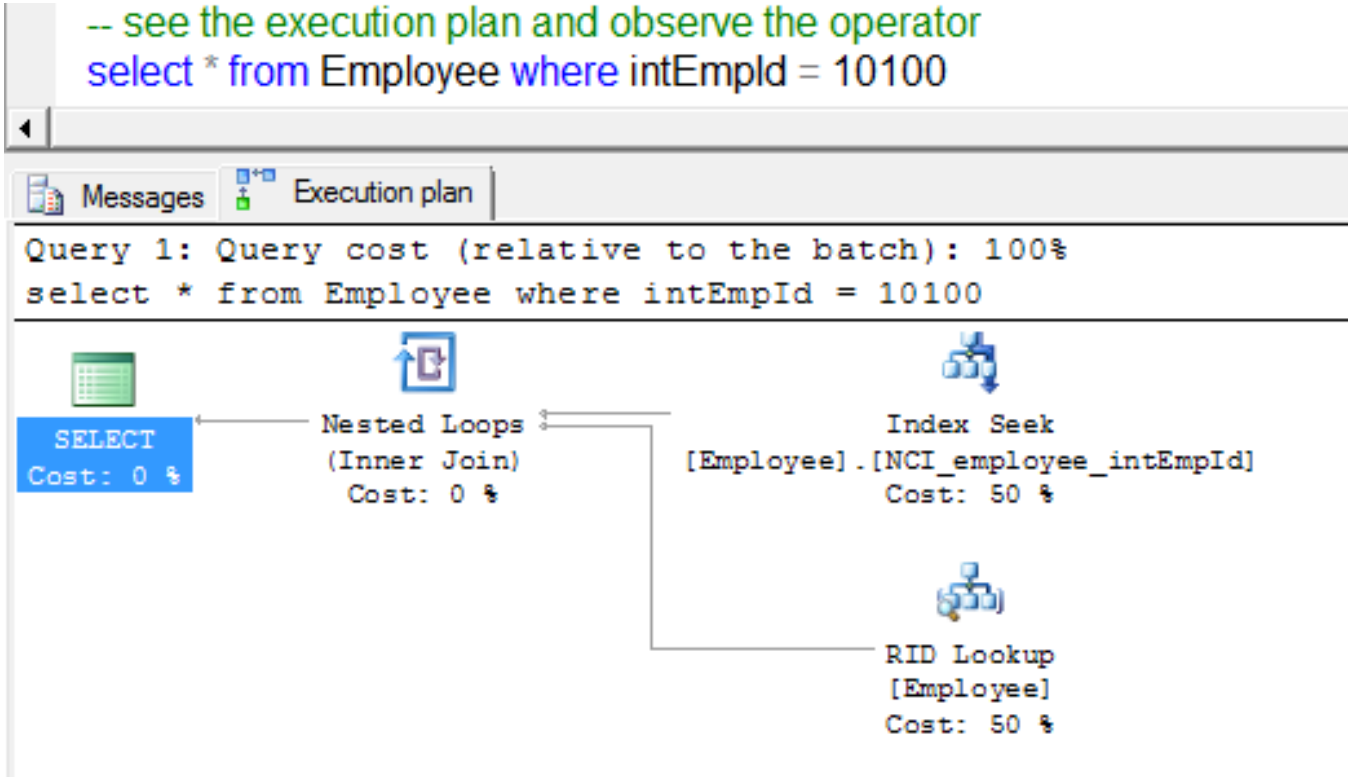
- Index_id > 1 and < 249
- Only Index entries in all B-Tree Levels
- Need to refer Heap or Clustered Index to fetch a record (Lookup)



http://technet.microsoft.com/en-us/library/cc917624.aspx

Reading records using Non Clustered Index

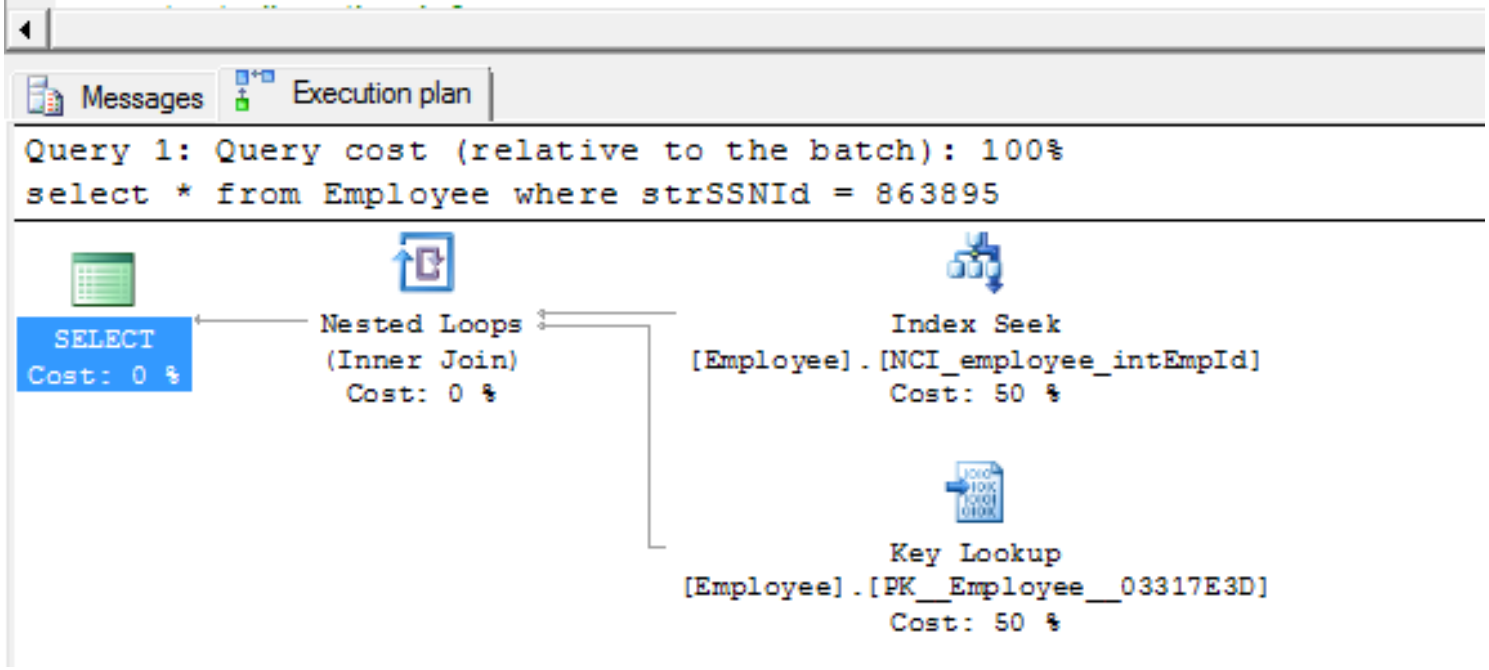
Reffering Heap with Non Clustered Index



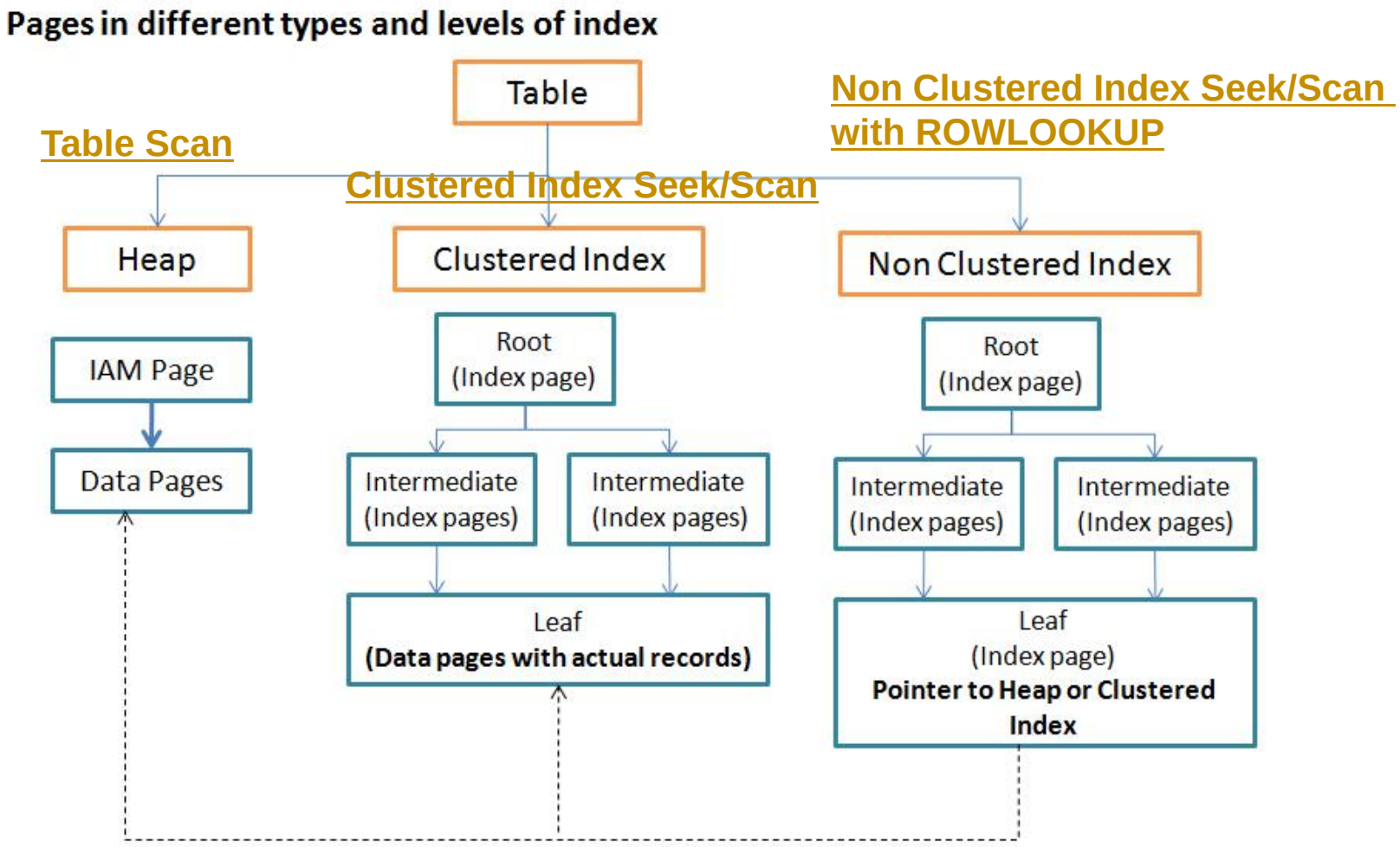
Reading records using Non Clustered Index

Reffering Clustered Index with Non Clustered Index

```
-- see the execution plan and observe the operator
select * from Employee where strSSNId = 863895
```



Sql Server Storage Internals –Index Structure



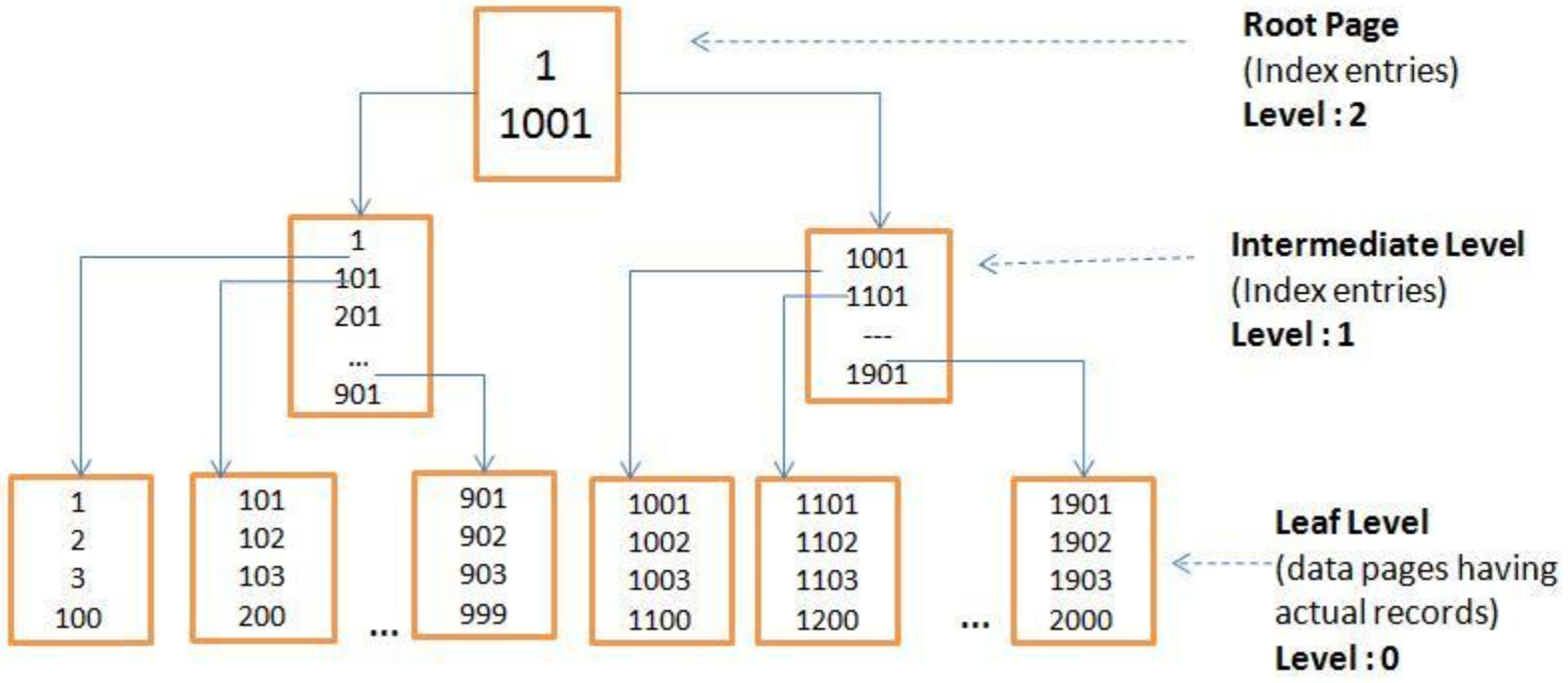
Sql Server Storage Internals – Indexes

Common Properties of Clustered and Non Clustered Indexes:

1. Indexes are organized as B-trees.
2. Each page in an index B-tree is called an index node.
3. The top node of the B-tree is called the root node.
4. The bottom level of nodes in the index is called the leaf nodes.
5. Any index levels between the root and the leaf nodes are collectively known intermediate levels.
6. Each index row contains a key value and a pointer to either an intermediate page in the B-tree, or a row in the leaf level of the index.
7. The pages in each level of the index are linked in a doubly-linked list.

Sql Server Storage Internals – Clustered Indexes

Clustered Index Architecture:



Sql Server Storage Internals – Reading Clustered Index Root Page

M_type = 2 indicates this is an Index Page

M_Level = 0 Leaf page
M_Level > 0 Intermediate or Root page
In this case 1 refers Root page

PageId (in Fileno:PageNo format)

Page @0x05686000

m_pageId = (1:265) m_headerVersion = 1 m_type = 2
m_typeFlagBits = 0x0 m_level = 1 m_flagBits = 0x8000
m_objId (AllocUnitId.idObj) = 121 m_indexId (AllocUnitId.idInd) = 256
Metadata: AllocUnitId = 72057594045857792
Metadata: PartitionId = 72057594041401344 Metadata: IndexId = 1
Metadata: ObjectId = 949578421 m_prevPage = (0:0) m_nextPage = (0:0)
pminlen = 11 m_slotCnt = 6 m_freeCnt = 8018
m_freeData = 162 m_reservedCnt = 0 m_lsn = (3575:1163:10)
m_xactReserved = 0 m_xdesId = (0:0) m_ghostRecCnt = 0
m_tornBits = 0

No. of index entries in this index page : 6

Minimum length of Index row. Here its 11

& Demo

Child pages of Root page. Forming B-Tree

Root page

Clustered Index Keys

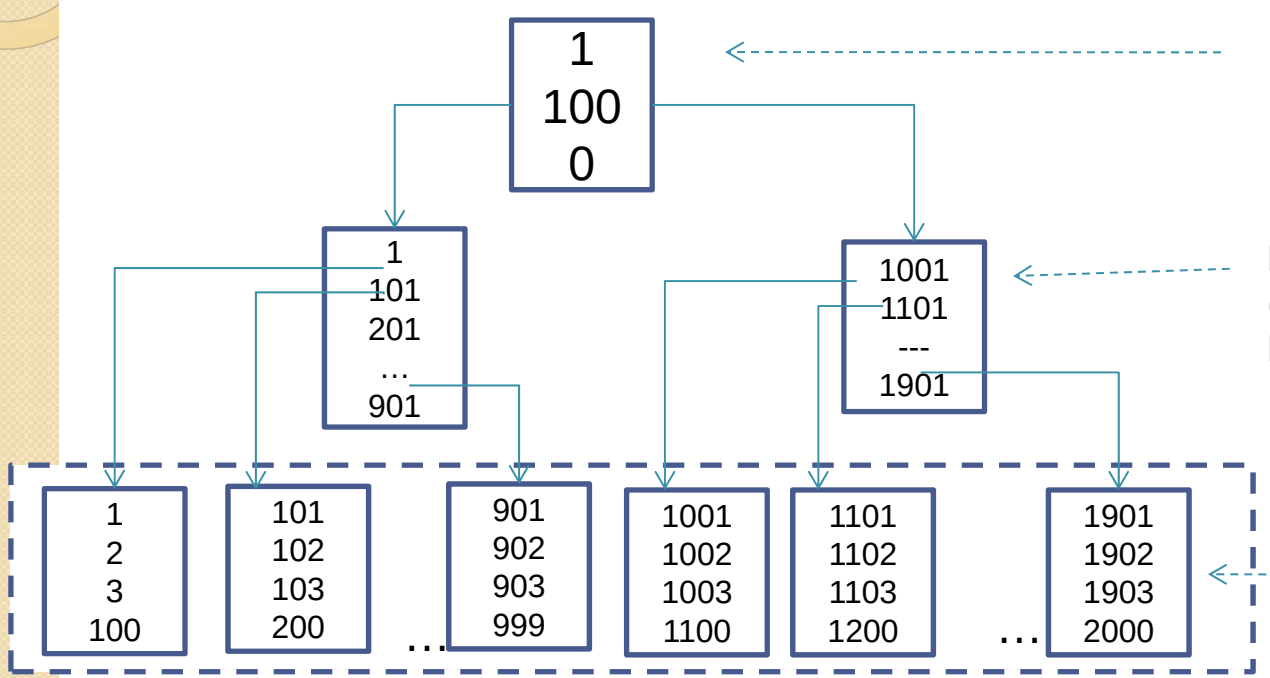
FileId	PageId	Row	Level	ChildFileId	ChildPageId	intEmployeeId (key)	UNIQUIFIER (key)	KeyHashValue
1	265	0	1	1	247	NULL	NULL	(01006a166b55)
1	265	1	1	1	261	1189	NULL	(010071a2c678)
1	265	2	1	1	266	1377	NULL	(010027b2a520)
1	265	3	1	1	263	1565	NULL	(0100fa6acfd2)
1	265	4	1	1	268	1753	NULL	(0100fbedce05)
1	265	5	1	1	269	1941	NULL	(01009e8a72bd)

To fetch Employeeid value 1200:

1. Query engine first check root page and examine employeeid range valu
2. Page number 261 is picked as this is the first page b/w Employee range 1377

Sql Server Storage Internals – Non Clustered Indexes

Non Clustered Index Architecture:



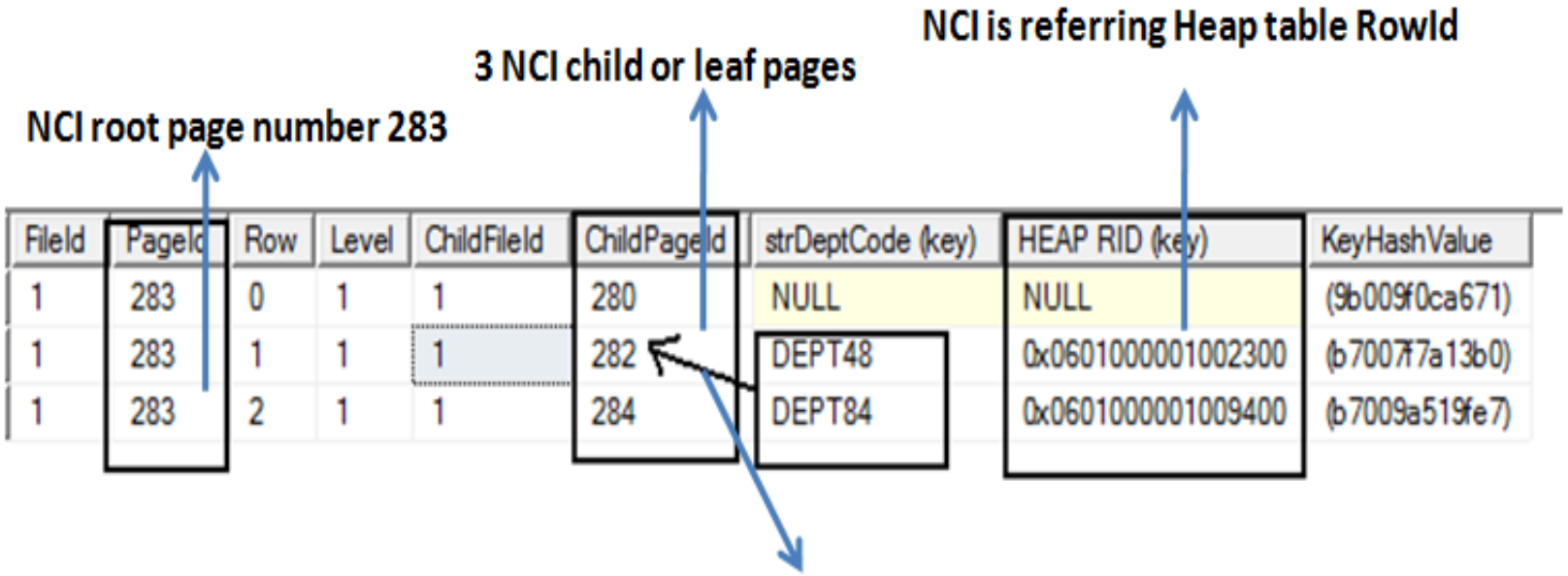
Root Page
(Index entries)
Level : 2

Intermediate Level
(Index entries)
Level : 1

Leaf Level
Pointer to
1. Index Key for Clustered Indexes
2. Row Id for Heap tables
Level : 0

Sql Server Storage Internals – Reading Non Clustered Index Root Page

Non Clustered Index Page of Heap

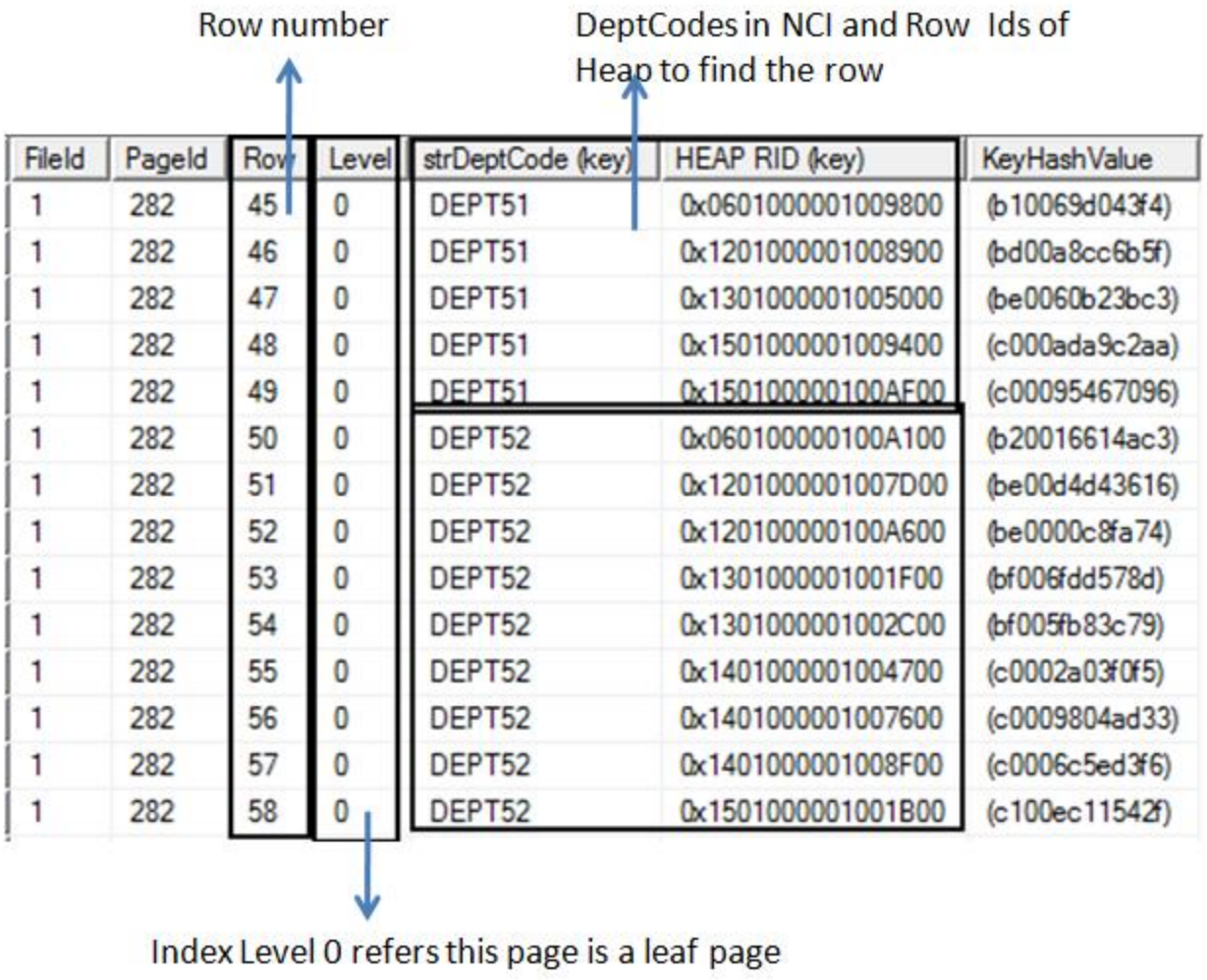


To fetch Dept value DEPT50:

1. Query engine first check root page of NCI and examine DeptId range values
2. Page number 282 is picked as this is the first page b/w Dept range 48 and 84

Sql Server Storage Internals – Reading Non Clustered Index Leaf Page

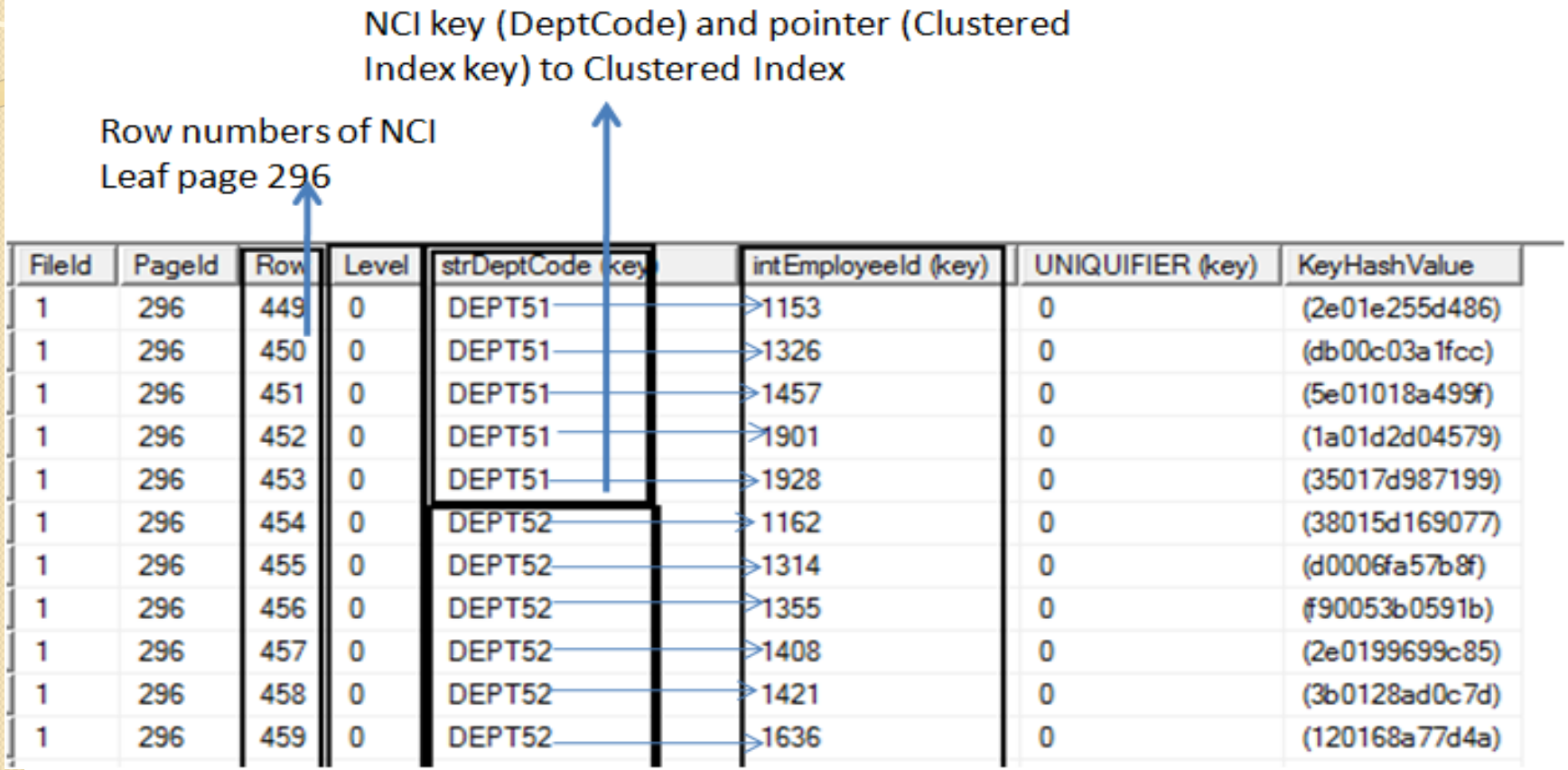
Non Clustered Index Page of Heap



FileId	PageId	Row	Level	strDeptCode (key)	HEAP RID (key)	KeyHashValue
1	282	45	0	DEPT51	0x0601000001009800	(b10069d043f4)
1	282	46	0	DEPT51	0x1201000001008900	(bd00a8cc6b5f)
1	282	47	0	DEPT51	0x1301000001005000	(be0060b23bc3)
1	282	48	0	DEPT51	0x1501000001009400	(c000ada9c2aa)
1	282	49	0	DEPT51	0x150100000100AF00	(c00095467096)
1	282	50	0	DEPT52	0x060100000100A100	(b20016614ac3)
1	282	51	0	DEPT52	0x1201000001007D00	(be00d4d43616)
1	282	52	0	DEPT52	0x120100000100A600	(be0000c8fa74)
1	282	53	0	DEPT52	0x1301000001001F00	(bf006fdd578d)
1	282	54	0	DEPT52	0x1301000001002C00	(bf005fb83c79)
1	282	55	0	DEPT52	0x1401000001004700	(c0002a03f0f5)
1	282	56	0	DEPT52	0x1401000001007600	(c0009804ad33)
1	282	57	0	DEPT52	0x1401000001008F00	(c0006c5ed3f6)
1	282	58	0	DEPT52	0x1501000001001B00	(c100ec11542f)

Sql Server Storage Internals – Reading Non Clustered Index Page

Non Clustered Index Page – Referring Cluster index Key



FileId	PageId	Row	Level	strDeptCode (key)	intEmployeeId (key)	UNIQUIFIER (key)	KeyHashValue
1	296	449	0	DEPT51	1153	0	(2e01e255d486)
1	296	450	0	DEPT51	1326	0	(db00c03a1fcc)
1	296	451	0	DEPT51	1457	0	(5e01018a499f)
1	296	452	0	DEPT51	1901	0	(1a01d2d04579)
1	296	453	0	DEPT51	1928	0	(35017d987199)
1	296	454	0	DEPT52	1162	0	(38015d169077)
1	296	455	0	DEPT52	1314	0	(d0006fa57b8f)
1	296	456	0	DEPT52	1355	0	(f90053b0591b)
1	296	457	0	DEPT52	1408	0	(2e0199699c85)
1	296	458	0	DEPT52	1421	0	(3b0128ad0c7d)
1	296	459	0	DEPT52	1636	0	(120168a77d4a)

Demo